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DIRECT SEEDING OF PINES IN THE CENTRAL HARDWOODS REGION

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Errata

(for Technical Paper 138, "Growth of planted red and white pine in Ohio and Indiana")

Page 4, paragraph 3, line 10:

Change "(fig. 3)" to "(fig. 4)"

Page 5, figure 3, caption:

Change "white pine" to "red pine"

Page 5, figure 4, caption:

Change "red pine" to "white pine"

CONTENTS

	Page
Recent experiments in Ohio and Illinois.	1
Seeding in spots	1
Seeding in furrows	3
Significant vegetational cover types in Illinois	3
Results - Seeding in spots	4
Results - Seeding in furrows	6
Machine-seeded pilot plants.	8
Costs of direct seeding	9
Discussion	10
Conclusions and recommendations	12
Seeding in furrows	12
Seeding in spots	14
Literature cited	15
Appendix	16
Catch percentages by years - Ohio	16
Tables	18

Frontispiece.--Typical cover for the direct seeding experiments.

DIRECT SEEDING OF PINES IN THE CENTRAL HARDWOODS REGION

by

Leon S. Minckler and Arthur G. Chapman[1/]

In reforestation work, direct seeding may have several advantages over planting nursery stock. The more efficient methods of direct seeding are cheaper and easier than either hand or machine planting. Direct seeding frees reforestation activities from complete dependence on nursery production and relieves the pressure on nursery operation (2).[2/] Where local seed trees are available, farmers or other landowners can collect their own seed and reforest idle land with a minimum of expense. Moreover, Tinsley (5) points out that trees grown by direct seeding have a more natural root system and there is a greater chance for natural selection to eliminate weak individuals. In general, direct seeding can probably be most useful when there is not enough planting stock, manpower, or money to meet the needs of ordinary planting.

On the other hand, direct seeding has one big disadvantage that tends to offset all its advantages. And that is its uncertainty. Results of the limited research done in recent years on pine direct seeding in eastern United States have been erratic. It seems that it is almost impossible to forecast the results of a direct seeding operation.

RECENT EXPERIMENTS IN OHIO AND ILLINOIS

Several direct seeding experiments have been carried on in Ohio and Illinois during the past two decades. Seeding has been tried both on seed spots and in plowed furrows. The results of some of these studies are reported here and some recommendations given for those who wish to try reforesting by direct seeding.

Seeding in Spots

Seed-spotting experiments were carried on over a 6-year period on old fields in southern Ohio. Altogether these tests involved about one hundred random plots averaging one-fifth acre each on northerly and southerly aspects.

1/ Silviculturist, Carbondale Forest Research Center, and Chief, Division of Forest Management, respectively.

2/ Numbers in parentheses refer to Literature Cited, p. 15.

Plots were established on typical old fields with a moderate cover of perennial grasses, mainly poverty grass and broomsedge grass (Danthonia spicata L. and Andropogon virginicus L.) (frontispiece), mixed with annual herbs and scattered small clumps of blackberry. Excessively bare and eroded areas and those with dense, tall cover were avoided.

The species tested at various times during the series of experiments were Virginia pine (Pinus virginiana Mill.), pitch pine (P. rigida Mill.), shortleaf pine (P. echinata Mill.), loblolly pine (P. taeda L.), eastern white pine (P. strobus L.), and red pine (P. resinosa Ait.).

Seeding was done by hand. A shallow cup-shaped spot not more than three-fourths of an inch deep and 4 to 5 inches in diameter was made with a hand-weeding, rake-like tool (fig. 1). Seed was placed in the spot and covered with one-eighth to one-fourth inch of sifted mineral soil. This was done to assure uniform covering of the seed. Top soil from the planting area was prepared by sifting through 6-mesh-to-the-inch hardware screen and was carried by the planter in small containers.

Figure 1.--Hand-weeding tool used in Ohio seeding tests.

The rate of seeding, or number of seeds placed in each seed spot, was varied with the viability of the seed. Based on cutting tests, the average number of seeds needed to assure at least one viable seed per spot was calculated. This number was then multiplied by an arbitrary safety factor. The factor varied from 9.5 for 5 to 9 percent viability down to 1.0 for 90 to 94 percent viability; that is, the better the viability the lower the safety factor. Ordinarily 5 to 20 seeds were sown per spot.

In Illinois six spot-seeded plots in each of 12 experimental blocks distributed over two Ranger Districts and the Kaskaskia Experimental Forest were studied. Planting sites having vegetational types ranging from a light cover of annual weeds and grasses to dense broomsedge with scattered brush were sampled.

Shortleaf pine was seeded in both late fall and spring; loblolly was seeded only in late fall. Cutting tests showed both loblolly and shortleaf pine to be 78 percent sound. Stratified seed was used for spring sowing. A plot consisted of 44 seed spots.

A spot about 6 to 8 inches in diameter was prepared by scalping with a mattock and chopping the surface slightly. A drill line about one-fourth inch deep was made across the spot with a sharp stick. A total of 15 to 20 shortleaf pine seeds was sown in the drill and covered with about one-eighth inch of soil; 12 to 14 loblolly pine seeds were sown per spot and covered about one-fourth inch deep. Fall seeding was done December 29 and 30, and spring seeding on March 30 and 31.

Seeding in Furrows

In conjunction with the seed-spot experiments in Illinois, tests of seeding in plowed furrows were also made. The species, seed source, and time of planting were the same as for the seed-spot tests. A plot consisted of 264 feet of plowed furrow.

A shallow, flat-bottomed furrow was plowed on the contour about 3 weeks before seeding, with furrow slices always thrown toward the downhill side. All furrows were plowed in December. Seed was dropped in furrows by hand[3/] at the average rate of three seeds per linear foot of furrow for loblolly and four for shortleaf pine. No effort was made to cover the seeds. Spring seeding was done on March 30 and 31 in furrows plowed the previous December.

Significant Vegetational Cover Types in Illinois

Since these old fields were abandoned in the mid-thirties, planting sites have advanced ecologically to various stages of cover succession. Three cover types were recognized. Two of them have four experimental blocks and one has three. One block was burned over and eliminated. The three types are as follows:

3/ To simulate Planet Jr. push-type mechanical seeder which, at the last moment, was unavailable. It was also impossible to plow furrows 60 to 90 days before seeding, as planned.

Cover type	Approximate density[4/]
Annual weeds and grasses	0.2 - 0.7
Mixed broomsedge and annual weeds and grasses	0.5 - 0.8
Broomsedge or broomsedge plus a light cover of sassafras, persimmon, and hickory	0.7 - 0.9

The stage of development of these types depends upon how long the field has been abandoned, how badly the land was eroded, and how good the site was in the first place. The better soils pass quickly through the successional stages to the mixture of broomsedge and sassafras, persimmon, and hickory. Areas subject to severe erosion may stay nearly bare or in the annual-weeds-and-grasses stage for 10 years or more.

RESULTS - SEEDING IN SPOTS

In general, the results of seed-spotting were unsatisfactory.

Germination and catch (percent of spots with at least one seedling) in southern Ohio varied from year to year and from place to place but were generally low (table 1 - Appendix). Because of the close spacing used (4 by 4 feet) and the numerous seedlings in many successful spots, the total number of trees per acre was sometimes adequate. However, these trees were often poorly distributed over the area. Moreover, when several seeds germinate in one spot, the trees have poor form and the crowns are extremely eccentric (fig. 2).

Figure 2.--When too many seedlings are crowded into a small space, they become spindly, retarded, and poorly formed.

4/ Percent of ground covered or shaded by vegetation.

Weather conditions from year to year seemed to have no distinct effect upon seeding success. One obvious reason for this is that there are so many things other than weather that influence the results. The great variation in success from place to place and spot to spot for the same year could not always be explained by prevailing conditions. In general, best seeding success was obtained on northerly slopes with a moderate cover of perennial grasses and annual herbs. Partly shaded spots did better than wholly exposed spots. Barren areas or areas with bluegrass sod or dense brush were very unfavorable.

Virginia pine was the most consistently successful of any species tried in Ohio, although the comparative success of the species varied greatly from year to year and place to place. In one experiment, Virginia pine failed almost completely.

Certain plots in some years were highly successful. But it is not possible from the present data to definitely identify the favorable conditions, duplicate them in another place or another year, and expect the same good results. These same unexplainable variations between years and between places were found in the Illinois experiments and also in experiments in Virginia (2).

In southern Illinois, the seed-spotted pine plots were a near failure by June of the second summer (table 2 - Appendix). First summer success was good except on areas of annual weeds and grasses, but frost heaving the first winter caused heavy mortality. The best catch (52 percent) was obtained with shortleaf pine in the broomsedge and light brush cover. Catch in annual weeds and grasses was only 22 percent. Loblolly was generally less successful than shortleaf pine. This is contrary to past results (2, 3) and could have been caused by poorer loblolly seed or the different conditions in this particular area.

Frost heaving could be reduced by applying a light mulch to the seed spots after sowing. This would add to the cost, but might be desirable for small areas on sites with plenty of mulch within easy reach. Frost heaving could also be reduced by disturbing the ground as little as possible in preparing the seed spot; this might be done by scratching an area 4 to 5 inches across between clumps of broomsedge as was done in the Ohio experiments. It was planned to use this method in the Illinois study, but trial in the heavy cover indicated it could not be used without real danger that the young pine seedlings would be starved out by overtopping vegetation. A 6- to 8-inch bare spot was prepared instead. The results indicate that such spots are subject to frost heaving.

RESULTS - SEEDING IN FURROWS

Seeding in furrows was successful on experimental plots with broomsedge or broomsedge and light brush and with mixed broomsedge and annual weeds and grasses (fig. 3). It was a failure in cover types of annual weeds and grasses (table 3 - Appendix). A comparison of results from examinations the first and fourth summers shows that losses through frost heaving or other causes were much less for furrows than for seed spots. Losses did occur, but enough seedlings remained to provide an acceptable stand except where annual weeds and grasses predominated.

Figure 3.--Shortleaf pine seeded in furrows.

Frost heaving losses were kept down by a natural accumulation of mulch material in the bottom of the furrows. This accumulation was very spotty or lacking on areas that had annual weeds and grasses. Previous work (3) has shown better results in furrows if a light mulch is raked into the furrows after seeding. This helps prevent excessive furrow washing and reduces frost heaving. The cost, however, is high and success without hand mulching was good enough to warrant the omission of this step. These plot tests in Illinois also show that in cover types where broomsedge predominates a mulch may not be necessary.

In the broomsedge cover types, fall-sown loblolly was slightly more successful than fall-sown shortleaf (table 3 - Appendix). Shortleaf sown in early March was also more successful than fall-sown. This is probably because the fall-sown furrows washed more and had excessive covering. During the first winter, furrow washing occurred while seed was in the furrows. By March the furrows had "settled" and the spring-sown stratified seed germinated before too much covering occurred.

Whether sown by hand or with the Planet Jr. (fig. 4), seeds are placed on top of the soil in the furrows. Some covering by rain, frost action, and slight washing is desirable and always occurs if the seed is sown at the proper time, that is, fall or early March. To avoid excessive washing and covering, furrows should be plowed on the contour at least 6 to 8 weeks before seeding. In the present case, through unavoidable circumstances, furrows were plowed only 3 weeks before fall seeding.

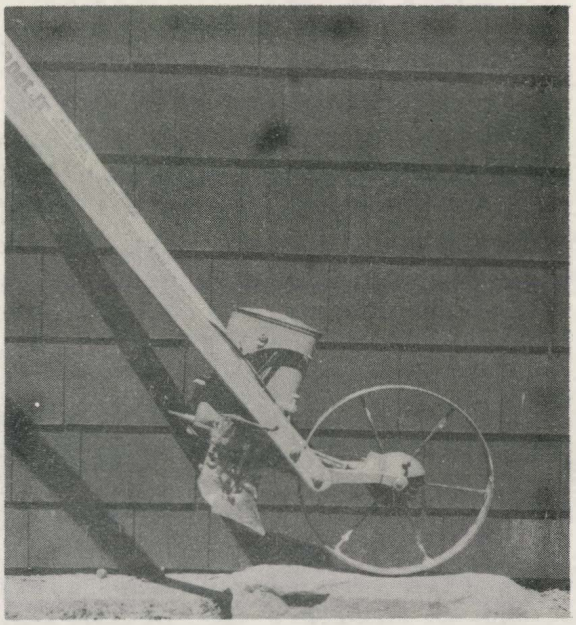

Figure 4.--The stripped-down Planet Jr. seeder can be used at a normal walking pace to place seed in the plowed furrows. It distributes seed evenly along the furrow at a density that can be regulated by a simple adjustment.

Table 3 (Appendix) shows the number of live seedlings in the average 8-foot section of furrow. If furrows were plowed 6 feet apart, one seedling per 8-foot furrow section would result in adequate stocking (about 900 trees per acre). For all broomsedge covers combined, 60 percent of the 8-foot furrow sections for spring-sown shortleaf had at least one seedling. For fall-sown shortleaf the figure was 54 percent and for fall-sown loblolly, 61 percent. Distribution in the furrows approaches a random arrangement on the successful experimental blocks. Distribution on the failed areas was very spotty and seedlings were concentrated in a few especially favorable spots in the furrows. Even in favorable cover types, local small areas had few seedlings and sheltered or

mulch-covered spots in the furrows had more seedlings. On larger areas, with furrows plowed 6 or 8 feet apart, these local conditions and chance variations would tend to be randomized from furrow to furrow and thus promote a satisfactory distribution over the whole area. This occurred on the pilot-plant seedings established on the Virginia Piedmont (3) and in one of the loblolly pilot plants described below.

MACHINE-SEEDED PILOT PLANTS

Because of the success of seeding in furrows in broomsedge cover, two pilot-plant tests of about 1 acre each were established on broomsedge areas and seeded with a Planet Jr. seeder in March 1950. Shallow, flat-bottomed furrows plowed on the contour with the furrow slice thrown downhill had been made the previous fall. One area was plowed with a team of horses and one area with a tractor. Half of each area was sown with shortleaf and half with loblolly pine seed, both unstratified. About four seeds per linear foot were sown. Cutting tests showed shortleaf to be 97 percent sound and loblolly 75 percent sound.

The tractor-plowed loblolly pilot plant had 1.7 live seedlings for the average 8-foot section of furrow when examined in June 1951. With furrows 6 feet apart, this seedling catch is equivalent to 1,544 trees per acre. Distribution over the area was good, and unless something unusual happens, this will be a successful loblolly pine plantation with little or no uneconomic thinning needed.

The tractor-plowed shortleaf pilot plant, which was next to the loblolly and sown at the same time, was a complete failure. No germinated seedlings were noted at any time and no seedlings could be found in June of the second summer.

The team-plowed pilot plant, about 10 miles away, was sown at the same time with the same seed but was a failure for both shortleaf and loblolly pine. The seed did not germinate and no reasonable explanation is apparent. Tractor plowing gave a much cleaner and more uniform furrow, but it is difficult to believe this made all the difference. McQuilkin (2) reported a similar experience: Success varied from place to place with no apparent reason.

At first glance the complete failure of shortleaf on both areas might appear to be caused by the use of unstratified seed. Yet there were about 6 weeks of weather too cold for germination during which the seed could have after-ripened in the cold, damp soil of the furrows. In the Illinois experimental plots, December-sown shortleaf germinated. And unstratified early March-sown

loblolly germinated on the tractor-plowed pilot plant. Ordinarily, unstratified southern pine seed will germinate in the nursery when sown in the fall or early spring. The Ohio tests showed good germination of dry seed of the four pine species even when sown in April (1).

In the fall of 1950, a 10-acre broomsedge field in southern Illinois was furrowed with a Jeep-drawn hydraulic-operated plow (fig. 5) that made a furrow about 2 to 3 inches deep and 10 inches wide. In March 1951, about half the field was seeded to shortleaf pine and half to loblolly using a Planet Jr. seeder. Seeding was at the rate of 5 to 6 seeds per linear foot for shortleaf and 3 to 4 seeds per linear foot for loblolly. Cutting tests on the loblolly showed 84 percent of the seeds were sound. The shortleaf seed had a germination test of 60 percent in the spring of 1950. Because of the early March sowing, the seed was not stratified. On this 10-acre pilot plant some loblolly and shortleaf pines did germinate, but when examined in late July and September of the first summer, seedlings were so scattered that the seeding must be counted a practical failure. The reason is not apparent and can only be laid to the unknown weather, site, or seed conditions that plague direct seeding projects.

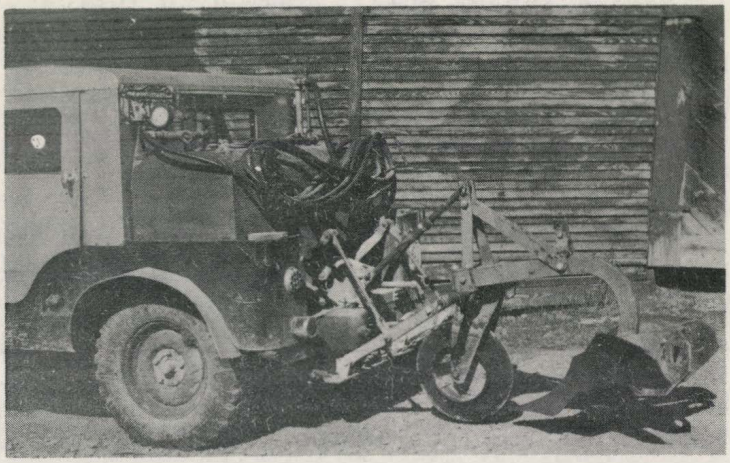

Figure 5.--A Jeep equipped with hydraulic lift and attached fire plow. This outfit, with outside wings of the plow removed, plows a shallow, flat-bottomed furrow about 10 inches wide.

COSTS OF DIRECT SEEDING

Actual costs of direct seeding were obtained from the various pilot plants as shown in tables 4 and 5 (Appendix).

It is noteworthy that only .64 man-hours of labor were spent per acre. Jeep operation costs would be very low even if the 10-cent-per-mile rate were doubled. The cost of seed is the critical item. If a landowner could collect his own seed from a logging operation, his labor and out-of-pocket expenses for direct seeding could be very low indeed.

Other work (2, 3) on a pilot-plant basis has shown that hand seeding in a mattock-prepared spot is several times more expensive than the above method and almost as costly as planting nursery-grown stock by the commonly used slit hand method. Cost in man-hours to establish the Ohio seed-spot plantations was about half that of planting seedling trees by the mattock side-hole hand method.

In Illinois half an acre was hand seeded by drill-sowing in prepared spots about 6 to 8 inches in diameter. The seeding required 12.7 man-hours per acre. This is almost equal to the time required for planting by the bar or mattock-slit hand method.

Because of the low cost of seed as against the comparatively high cost of nursery stock, the over-all cost of direct seeding was less than half that for hand planting trees. The cost of seed is very variable, but usually should be less than the cost of planting stock. If seed could be obtained for 6 dollars per pound, shortleaf seed for an acre would cost about 2 dollars as compared with at least 5 dollars for planting stock.

If mulch is required either on seed spots (2) or in furrows, total cost is of course increased. On a pilot-plant area in Virginia, raking a light mulch in furrows required 5.2 man-hours per acre as contrasted with 1.0 team-hour for plowing and 0.7 man-hours for seeding (3).

DISCUSSION

Seeding pines, both in spots and in furrows, produces erratic results. This is the chief practical lesson learned from the present series of studies in southern Ohio and Illinois. Failures may occur from year to year in the same place or from place to place in the same year. Success can be obtained on some occasions and the lower cost of the machine method may make its use possible under certain special conditions.

Related to the erratic behavior is the occurrence of dense groups of seedlings when success is good (4). This adds an early thinning cost, which, in turn, adds to the total cost of establishing a stand by direct seeding. This clumping probably cannot be avoided with seed-spotting methods. If only three or four seeds are used per seed spot, there is an increased danger of failure. If using 10 to 12 viable seeds per spot fails, using more is probably useless. A mechanical seeder scatters the seed over the whole length of the furrow and no more than three or four seeds are placed on any 1 foot of furrow. Therefore, the chances of dense groupings are greatly reduced. Such groups do occur occasionally, however, and they may make early thinnings necessary.

The general causes of variations in success can be stated, but the specific causes in any given case cannot always be verified and control may not be possible. The factors influencing success are listed and briefly discussed below:

Seed quality.--This can be all important and no seeding should be done unless seed is tested for viability. The seed of southern pine usually germinates well under proper conditions. Fall seeding or seeding in the spring about 6 weeks before germinating temperature is attained usually provides opportunity for after-ripening. Seed for late spring sowing should be stratified about 6 weeks. Viable seed in a condition to germinate is the first prerequisite for successful seeding because germination is the most common point of failure in direct seeding. Seed quality can usually be at least partially controlled.

Weather.--The success of direct seeding can be determined by the weather, either through its effect on germination or on later seedling survival. A drought or hard freeze at a critical time can eliminate most seedlings. Weather of course varies from year to year, but it cannot always be correlated with success and it cannot be predicted or controlled.

Location.--The effects of location are usually indefinite and impossible to determine. Local rainfall distribution might play a part, or some aspect of soil or site may interfere. It is difficult to explain variable results between apparently similar sites seeded the same year with the same seed, yet they do occur.

Cover.--It has been shown in this paper and elsewhere (3) that cover vegetation influences seeding success. This can be controlled in a broad sense by seeding only areas with favorable cover.

Frost heaving.--This may be an important cause of mortality the first winter, and to a less extent the second winter. It can be partially controlled by selection of cover types and method of seeding, and by mulching.

Rodents and birds.--Plowing furrows several months in advance of seeding will minimize seed losses from rodents and birds. On occasion, however, rodents and birds can cause complete failure of seeding.

Diseases and insects.--Damping off and cut worms occasionally cause heavy losses but they are apparently not usual limiting factors.

"Accidental" conditions.--Accidents or gross mistakes in methods or technique may occasionally cause direct-seeding failure. An example is too deep covering of seed by improper technique or excessive washings. Human mistakes can be controlled by careful planning and supervision. Conditions within a furrow may vary enough to influence seeding success almost foot by foot. A bit of shade or mulch or a moist spot has been observed to increase germination both in the Ohio and Illinois experiments. A section of furrow through a "galled" spot with no top soil and scanty vegetation may have no seedlings. In suitable cover types these furrow variations do not seem to affect over-all distribution of seedlings.

CONCLUSIONS AND RECOMMENDATIONS

Although less expensive than planting seedlings in the Central States, hand-seeding methods are still too expensive and subject to failure and often result in dense clumps of spindly, poorly formed trees unless thinned. Mechanized ground preparation and seeding, also subject to erratic results, are very cheap and may be useful under certain special conditions, such as:

1. An extensive reforestation program where it is necessary to cover large areas in a short time.

2. A situation where enough planting stock is not readily available but seed is available or can be collected economically.

3. When man-power and money are scarce but seed is plentiful. For example, a landowner might collect seed from a logging operation and seed relatively large areas almost single-handed.

It should be realized that direct seeding, whether done by hand or machine, may result in failure or near failure so the expense must be low enough to permit reseeding without running the total cost above cost of planting. If planting stock and a tree planting machine are available, machine seeding must be considered in relation to machine planting.

Seeding in Furrows

If seeding in furrows is done in the Central Hardwoods region, the following steps are recommended:

1. Seed only areas with a cover of perennial grasses that do not form sod, such as broomsedge or poverty grass, or these grasses mixed with scattered brush or annual weeds and grasses. Avoid bare or sparsely covered areas, heavy sod, or tall dense vegetation.

2. Furrows should be plowed approximately on the contour, 6 to 8 feet apart. Furrows should have flat bottoms and be about 2 to 3 inches deep and 6 to 10 inches wide depending upon equipment used. The furrow slice should be thrown toward the downhill side or, if on the uphill side, thrown far enough away from the furrow to prevent washing of loose soil back into the furrow. The steepness of the slope will tend to govern the practice used.

3. Furrows should be plowed with mechanized equipment wherever possible. A Jeep with attached plow throwing furrows both ways did the best and cheapest job. Furrow slices were thrown free from the furrow. A light tractor with attached plow was also satisfactory, but more expensive. The rougher areas might require a tractor. A light tractor equipped with two moldboard plows set for side-hill work (furrow slice always thrown downhill regardless of direction of travel along slope) would be satisfactory. Team-plowing can be successful (3) although it is slow and costly compared with mechanized equipment.

4. If seeding is done in the late fall, plowing should be done in early September or at least 6 to 8 weeks before seeding time. If seeding is done in the early spring, plowing should be done the previous fall. For fall sowing, or spring sowing earlier than about the first week in March, unstratified seed may be used. For later spring seeding, use stratified seed. Shortleaf pine seeds, because of their small size, are more likely to be covered too deep if sown in the fall.

5. Seed the furrows with a push-type mechanical seeder (Planet Jr. type). Make sure that the seeder will properly handle seed of the size to be used. Some seeders will not handle pine seed. Set the seeder to drop about three viable seeds per linear foot for loblolly, Virginia, and pitch pine and four for shortleaf pine. Do not use seed unless cutting tests show it to be at least 60 percent sound.5/ The seeder may be run along the bottom of the furrow at a regular walking pace. The seed should not be covered with soil but merely dropped in the bottom of the furrow. Seed will be covered by frost and water action. The mechanical seeder is used to obtain fast and better distribution of the seed and not for soil preparation or seed covering. On small jobs, seeding in furrows could also be done by hand.

Another step, although costly in labor, will usually add to the success of this seeding method and in some cases may make the difference between success and failure. Rake a very light mulch of dead grass or debris into the furrows from the upper side.

5/ By flotation methods, empty or other light seed may be separated from the sound or fully filled seed.

This mulch should not be over one-fourth inch deep before settling and no mulch is better than too much. This mulch will retard washing in the furrows, increase germination, and help prevent frost heaving.

Seeding in Spots

Seeding in spots is not generally recommended, but if farmers or others wish to do it on a small scale for reasons of economy or expediency, the following recommendations should be followed:

1. For recommendation on vegetational cover, time of seeding, seed stratification, and area protection see those given in the "Seeding in Furrows" section.

2. With a twisting movement of the hand weeder, prepare a shallow, cup-like bare spot 3 to 5 inches in diameter, depending upon the density of the vegetation. A groove may be scratched across this spot about one-fourth inch deep and the seed scattered along it. Cover with soil by leveling back the edge of the groove. Or, without a groove, scatter the seed over the prepared spot, cover with a small handful of screened soil from nearby, and firm. The larger-seeded species (loblolly pine) should be covered not more than one-fourth inch and the smaller-seeded species (shortleaf) not more than one-eighth inch deep.

3. If cutting tests show seed to be 80 percent sound or more, sow about six sound seeds per spot. If soundness is 60 to 80 percent, sow 10 to 12 seeds per spot. If seed is less than 60 percent sound, it should not be used for direct seeding. After practice, the proper number of seeds may be estimated by a gauged "pinch" of seed or a small "spoon" of the proper size may be constructed.

4. A very light mulch of dead plant material about one-eighth inch deep placed over the bare spot after seeding will usually improve success.

5. Seed spots should be spaced from 5 to 7 feet apart depending upon time, money, and seed available. Better results are obtained if spots are located in the partial shade of clumps of grass or other vegetation, without regard for strict spacing.

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APPENDIX

Catch Percentages by Years - Ohio

1936 - 1937

The seedling catch for plots established in 1936 was less than 10 percent for all species, aspects, and treatments. The same experiment was repeated in 1937. In that year, pitch pine failed completely because of poor seed. The average catch percentages at the end of the second summer for the 1937 plots are given below:

	Percent
Species:	
Virginia pine	17.4
Shortleaf pine	14.5
Seed spot location:	
Furrow bottom	17.2
Furrow ridge	11.6
Rough	18.7

1938

Six pine species were seeded in 1938 on north and south aspects. The average percent catch at the end of the second summer by species and aspects is tabulated below:

	North	South	Combined
Virginia pine	17.0	3.0	10.0
Pitch pine	2.5	1.5	2.0
Shortleaf pine	18.0	7.0	12.5
Loblolly pine	58.5	13.5	36.0
Eastern white pine	49.5	15.5	32.5
Red pine	1.5	0.0	0.8

1939

The results of the seedings of Virginia and shortleaf pines in the spring of 1939 were the best obtained from any of the six yearly studies. Seed for both species had a viability of over 90 percent. Ten seeds were placed in each prepared spot.

Seeding was done in eight places on northerly and southerly slopes. The average percent catch at the end of the second summer for all places combined is tabulated below:

	North	South
Virginia pine	76.0	49.5
Shortleaf pine	48.6	34.6

Different places exhibited the usual discrepancy in success. Combining both species and both aspects, percent catch ranged from 20.3 to 78.4 for the different places. No definite explanation for this can be given.

1940 - 1941

The results from seed sown in the spring of 1940 have been published by McLintock (1). Stratified seed gave better results than dry seed for Virginia, shortleaf, and pitch pines, but dry seed gave remarkably better results for loblolly pine. In the tabulation below, results from the test and treatment are given. The percent catch is shown for both the beginning and the end of the second growing season:

	Beginning of second growing season		End of second growing season	
	(North)	(South)	(North)	(South)
Virginia pine	66.4	43.8	66.8	42.2
Pitch pine	53.9	27.0	49.6	26.2
Shortleaf pine	43.8	26.6	43.4	21.5
Loblolly pine	44.5	35.9	43.8	30.5

This shows the small amount of mortality occurring during the second season and is typical of both the Ohio and Illinois experiments.

The last seeding tests of this series in southern Ohio were established in the fall of 1940 and the spring of 1941. Dry seeds of three species were sown in October and stratified seeds were sown during the following April. In these tests there was no difference in success between the north and south slopes. The species varied in their responses to season of sowing as shown by percent catch at the end of the second season:

	Percent catch fall seeding	Percent catch spring seeding
Virginia pine	56.2	64.5
Pitch pine	52.9	23.5
Shortleaf pine	20.8	20.1

The species mean differences are statistically significant but only pitch pine showed a significant difference between seasons of sowing.

Table 1.--Percent germination, survival, and catch for combined species by year and aspect, Ohio plots

Year established	Germination (first year)		Survival (second summer)		Catch[1] (second summer)	
	Aspect		Aspect		Aspect	
	North	South	North	South	North	South
1936	-	-	-	-	4.8	1.0
1937[2]	25.2	45.2	49.8	66.3	10.7	21.6
1938	18.4	7.7	40.0	15.4	24.5	6.8
1939	32.4	25.0	86.6	77.3	62.3	42.1
1940[3]	29.4	19.4	54.2	41.7	40.5	25.7
1941[4]	27.3	29.2	57.3	57.7	40.4	42.5

1/ Seed spots with one or more live seedlings.
2/ Excludes pitch pine which failed because of poor seed.
3/ Includes both stratified and dry seed plots.
4/ Includes both fall and spring sown plots.

Table 2.--Percent catch[1] of hand direct seeding by cover types, species, and time of sowing, Illinois plots

Species and time of sowing	Broomsedge and light brush[2]		Broomsedge and annual weeds and grasses[3]		Annual weeds and grasses[3]	
	June 1948	June 1949	June 1948	June 1949	June 1948	June 1949
Shortleaf pine (March 1948)	80	52	76	40	57	21
Shortleaf pine (December 1947)	74	52	62	23	46	22
Loblolly pine (December 1947)	59	39	38	23	34	25

1/ Percent of seed spots having at least one live seedling.
2/ Each value based on three plots of 44 seed spots each.
3/ Each value based on four plots of 44 seed spots each.

Table 3.--Average number of live seedlings per 8-foot section of furrow, by species and type, Illinois plots

Species and time of sowing	Broomsedge and light brush[1]		Broomsedge and annual weeds and grasses[2]		Annual weeds and grasses[2]	
	June 1948	June 1951	June 1948	June 1951	June 1948	June 1951
Shortleaf pine (March 1948)	1.8	1.7	2.5	1.2	0.1	0.1
Shortleaf pine (December 1947)	1.6	1.1	0.9	0.7	0.3	0.3
Loblolly pine (December 1947)	1.4	1.3	1.2	1.0	0.3	0.3

1/ Each value based on three plots each consisting of 264 feet of furrow.

2/ Each value based on four plots each consisting of 264 feet of furrow.

Table 4.--Cost per acre of direct seeding by species on the tractor-plowed pilot plant in Illinois, 1949-50

		Shortleaf pine	Loblolly pine
Plowing[1/]	0.87 tractor-man-hours @ $2.50	$2.17	$2.17
Seeding[2/]	0.92 man-hours @ $1.00	.92	.92
Seed	1/3 lb. @ $5.00	1.67	
	1 lb. @ $5.00		5.00
Total cost per acre		$4.76	$8.09

1/ Furrows were plowed 6 feet apart with a tractor-drawn plow.

2/ Seeding was done with a Planet Jr. mechanical seeder (fig. 4).

Table 5.--Cost per acre of direct seeding by species on a Jeep-plowed, 10-acre field in Illinois, 1950-51

		Shortleaf pine	Loblolly pine
Plowing[1/]	0.31 man-hours @ $1.10	$0.34	$0.34
	1.38 miles @ $0.10	.14	.14
Seeding[2/]	0.33 man-hours @ $1.10	.36	.36
Seed	0.45 lbs. @ $6.00	2.70	
	0.61 lbs. @ $6.00		3.66
Total cost per acre		$3.54	$4.50

1/ Furrows were plowed 6 feet apart with a Jeep-drawn plow (fig. 5).

2/ Seeding was done with a Planet Jr. mechanical seeder (fig. 4).

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